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GENERAL DYNAMICS | CONVAIR

Report No. 8926-169

Material - Finishes and Coatings - Zinc, Silver, Chromium, Nickel Plates

Effect of Electroplated and Chemically Plated Coatings on Strength, Corrosion, Heat Resistant and Abrasion Resistant Properties of 4340 Steel at 280,000 to 300,000 psi Ultimate Strength

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Abstract:

The several test findings were as follows: (1) significant ultimate and yield tensile strength losses did not result from plating; (2) reduction of area losses ranging 7 per cent for chemical nickel to 98 per cent for "electrolized" chromium occurred; (3) 55 and 84 per cent of elongation was lost for all but electrolytic and chemical nickel plate. Baking restored the losses found with silver plate and restored the losses experienced with zinc plating; (4) zinc plated coatings resulted in the higher fatigue life. Post plating baking at 375°F was detrimental in every case; (5) chemical nickel, silver, electrolytic nickel, "electrolyzed" chromium and zinc resisted 200, 96, 96, 48 and 48 hours, respectively, of salt spray corrosion; and chemical nickel coating showed the greater wear resistance.

Reference: Forney, D. M., Jr., Haney, R. J., Wise, W. E., "Metallic Protective Coatings - AISI 4340 Steel - 280,000 PSI UTS - Static, Fatigue, Wear, Corrosion and Heat Tests," General Dynamics/Convair Report MP 56-~~265~~ 425, San Diego, California, 27 August 1957. (Reference attached).

STRUCTURES & MATERIALS LABORATORIES

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A DIVISION OF GENERAL DYNAMICS CORPORATION

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REPORT NO. 56-623
METALLIC PROTECTIVE COATINGS
AISI 4340 STEEL - 260,000 PSI UTS
[illegible] FATIGUE, WEAR, CORROSION AND HEAT TESTS

MODEL F-106A

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STATIC, FATIGUE, WEAR, CORROSION AND HEAT TESTS
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INTRODUCTION:

Inasmuch as the design of steel aircraft parts has heretofore seldom required heat treatment to ultimate tensile strengths in excess of about 220,000 psi, investigations into the successful use of certain metallic protective coatings for parts heat treated to the 280,000 - 300,000 psi ultimate tensile strength range have been, for the most part, sketchy.

In view of the increasing use of high hardness steel and the growing need for plating data, a survey of the performance of several coatings deposited on high strength AISI 4340 steel was performed.

OBJECT:

The object of this test was to evaluate the relative performance of zinc, silver, electrolytic and chemical nickel and "electrolized" chromium coatings deposited on AISI 4340 steel heat treated to a nominal ultimate tensile strength of 280,000 psi. Examination was made of the static and fatigue properties, the effect of baking on these properties, the corrosion and thermal exposure resistance and the abrasive wear properties.

CONCLUSIONS:

The evaluation of the performance of zinc, silver, electrolytic and chemical nickel and "electrolized" chromium coatings on high hardness AISI 4340 steel was made in terms of their effect on specimen properties:

1. Ultimate Tensile and Yield Strength. - No significant changes resulted from any plating whether or not post-plating baking was performed.

2. Percent Reduction-in-Area. - Every plating type experienced a loss ranging from 7 percent for chemical nickel to 98 percent for "electrolized" chromium; however, baking restored the loss in all cases but zinc (no recovery for "electrolized" chromium - no baking is performed in process).

3. Percent Elongation. - A loss occurred rangingfrom 35 to 64 percent for all but electrolytic and chemical nickel (no reduction). Baking restored the loss suffered by silver and reduced the loss experienced with zinc from 48 to 11 percent (no recovery for "electrolized" chromium - no baking performed).

4. Fatigue Strength. - Zinc coated specimens exhibited a higher fatigue life at the 190,000 psi (R = +.05) test stress than any of the other types tested, as shown in the table below. Also illustrated is the fact that post-plating baking at 375°F for 3 hours was detrimental in every case:

Plating	Fatigue Life, Cycles - 190,000 psi (R = +.05) Test Stress	
	No Bake	Bake
Zinc	64,500	24,700
Silver	30,000	21,600
Electrolytic Nickel	23,600	18,500
Chemical Nickel	20,750	11,750
"Electrolised" Chromium	6,000	- - -

5. Salt Spray Corrosion Resistance. - A 250 hour exposure failed to significantly damage the chemical nickel coating; however, corrosion began after 200 hours with silver, 96 hours with electrolytic nickel and "electrolised" chromium and 48 hours with zinc.

6. Abrasive Wear Resistance. - The relative abrasive wear resistance, shown as Tabor Abrasion Wear Test cycles, is illustrated in the following table which shows base material hardness to be a factor:

Coating	Rockwell C 40	Rockwell C 47	Annealed C. R. Steel
Chemical Nickel	7500	10,400	---
Electrolytic Nickel	5800	2600	---
Zinc	2280	6200	---
Silver	3148	2836	---
"Electrolised" Chromium	---	---	5000

7. Thermal Exposure Resistance. - One hour furnace exposures at 700°F and 1000°F resulted in an extensive deterioration of zinc pl[illegible]. Silve[illegible] other hand, appeared to retain coating strength as well as luster at these temperatures. Electrolytic and chemical nickel and "electrolised" chromium appeared to be unaffected although they suffered oxidation discoloration.

TEST SPECIMENS AND PROCEDURES:

Five types of metallic protective coatings were deposited on high hardness AISI 4340 steel* specimens for evaluation in the course of this test, namely:

(1) Zinc, 0.001 ± .0001" per QQ-Z-325, Class I
(2) Silver, 0.0004-0.0006" per QQ-S-365, Type I
(3) Electrolytic Nickel, 0.003 ± .0001" per QQ-N-290, Class II
(4) Chemical Nickel, 0.005 ± .0001" per Convair Spec. 0-06009
(5) "Electrolised" chromium, 0.0004-0.0006" - Electrolising Corp.

All post-plating baking was performed on a 3 hour cycle at 375°F (including those cases where specification requirements conflicted).

Tensile Tests. - Standard tensile test specimens were made in accordance with Figure 1. Blanks were cut from 7/8" AISI 4340 steel round bar and rough machined prior to heat treatment. Following heat treatment, as outlined below, the specimens were finish ground:

a. Normalized at 1600°F for 4 hours
b. Air cooled
c. Austenitized at 1575°F for 4 hours
d. Oil quenched to below 200°F
e. Temper at 480°F for 2 hours
f. Air cooled

The specimens were divided into five groups, one for each type of coating investigated. Half of each group was baked at 375°F for 3 hours following the plating operation and the remaining half left unbaked.

The tensile tests were performed in a 200,000 pound Baldwin Universal Testing machine. Ultimate tensile and yield strength, percent reduction in area and percent elongation data were recorded.

* Except specimens No. 17-20, Table III

Fatigue Tests. - Fatigue specimens were rough machined from 1 1/8" AISI 4340 steel round bar and heat treated in the same furnace batch as the tensile specimens described above. The specimens were then finish machined to the requirements of Figure 2. Following the plating operation, half of each group was baked at 375°F for 3 hours and the remaining half left unbaked.

The axial load tests were performed in a Sonntag 10-U Fatigue Machine, with a 5 to 1 load amplifier, at a maximum stress of 190,000 psi and a stress ratio (R) of + 0.05. A test setup is shown in Figure 3.

Corrosion Tests. - Salt spray corrosion tests were performed as a further evaluation of the coatings. A portion of the tensile specimens described above and shown in Figure 1 were utilized for the tests. Half of the baked specimens and half of the unbaked specimens of each plating type were subjected to a 250 hour exposure in a salt spray booth. Prior to exposure, the unplated thread section of each specimen was coated with "Therma-dip" (CVAC-1050-50) in order to protect it from damage during the test. A close examination was made of the specimens every 24 hours in order to determine the exposure time to the first signs of corrosion. At the conclusion of the 250 hour period, the specimens were tensile tested to evaluate any changes in mechanical properties*.

Abrasive Wear Tests. - Tests were performed on each coating in order to determine relative resistance to wear. Two 4" x 4" x .125" blocks of AISI 4340 steel were cut for each coating type#, heat treated - one to Rockwell C 40 and the other to Rockwell C 47 - and finish ground. The two blocks in each case were then provided with the appropriate coating and baking treatment.

Each specimen was mounted for testing in a Tabor Abrasion Testing Machine as shown in Figure 5. Type CS-17 abrasion wheels were used under a dead weight preload of one kilogram. During the course of each test, the abrasion wheels were redressed each 500 cycles by replacing the test specimen with fine emery paper and running the machine 25 cycles.

In order to evaluate relative wear, the number of revolutions of the abrasion wheel needed to wear the plating and expose the base metal was determined. An acid solution, chosen to react with the base steel but not with the plating (or, at least, very slowly), was applied to the wearing surface periodically - thus, a reaction would indicate a breakthrough. A 1 to 1 water solution of hydrochloric acid was used with the silver plating and a 1 to 3 water solution of nitric acid with the zinc, electrolytic and chemical nickel and the "electrolized" chromium platings.

* Yield strength not determined - extensometer not used due to danger of premature failure of specimen.

\# Exception being those used for "electrolized" chromium. In this case, cold rolled steel pieces were used in annealed condition - tests were added to program at late date.

Thermal Exposure Tests. - Two AISI 4340 steel strips, 1" x 10" x .375", were cut for each plating type*, heat treated to Rockwell C 47 and finish ground. Two strips in each case were provided with the appropriate coating and baking treatment. One strip of each type was heated for one hour in a furnace at 700°F and the remaining strips were heated to 1000°F for one hour in the furnace. The strips were then examined to determine the relative effect of exposure to elevated temperatures. Figure 6 shows the strips after exposure. Specimens No. 1 and 2 are zinc plated, Nos. 3 and 4, silver plated, Nos. 5 and 6 are coated with electrolytic nickel, Nos. 7 and 8, chemical nickel and Nos. 9 and 10, "electrolized" chromium. Even numbered specimens were exposed to 1000°F and odd numbers to 700°F.

RESULTS AND DISCUSSION:

The results of the static tests are given in Table I and fatigue test results are presented in Table II. Table III gives the abrasion wear test results, Table IV the corrosion test results and Table V the thermal exposure test results.

Examination of the static test results of Table I indicates that no significant change occurred in the ultimate tensile strength as a result of plating, regardless of type or whether or not baking was performed. Likewise, the yield strength varied only about 2 percent. The reduction in area and elongation properties, on the other hand, were significantly affected, for the most part, by plating. The percent RA for zinc plating, for instance, suffered a loss of 78 percent, silver 44 percent and "electrolized" chromium as much as 98 percent. The percent elongation for zinc coated specimens was reduced 45 percent, for silver, 36 percent and for "electrolized" chromium, 84 percent. Baking at 375°F for 3 hours succeeded in restoring all losses excepting that experienced by zinc. In this case, however, the loss of percent RA was reduced to 26 percent and that of percent elongation to 14 percent.

Examination of Table II illustrates that zinc plated specimens exhibit the highest fatigue life of the group (at the test stress of 190,000 psi at R = +.05). The fatigue life of silver was only 47 percent as good as zinc, electrolytic nickel only 37 percent, chemical nickel, 32 percent and "electrolized" chromium only 7 percent as good. It is particularly interesting to note that baking at 375°F for 3 hours resulted in a general reduction of fatigue strength, ranging up to 62 percent in the case of zinc, 28 percent for silver, 71 percent for electrolytic nickel and 43 percent for chemical nickel. "Electrolizing", of course, does not include a baking step.

* Exception being those used for "electrolized" chromium - cold rolled steel pieces used in annealed condition - tests were added to program at late date.

The corrosion test results of Table III show that chemical nickel plating successfully resisted corrosion during a 250 hour salt spray booth exposure. Silver resisted damage for 200 hours, electrolytic nickel and "electrolized" chromium 96 hours and zinc 48 hours. The subsequent tensile tests of the corrosion specimens indicated no apparent loss in ultimate tensile strength occurred due to corrosion damage. Yield strength data were not obtained - no extensometer was used in view of the possibility of premature failure resulting from the corrosion damage. Percent RA and percent elongation data were obtained from the electrolytic and chemical nickel coated specimens only. These data show rather conclusively that corrosion damage of the plating results in a fairly drastic reduction in specimen ductility. No noticeable corrosion damage to chemical nickel coatings occurred and, as Table I shows, percent RA and elongation were not reduced. Damage to electrolytic nickel coated specimens, on the other hand, was accompanied by a loss in percent R.A. of 64 percent and in elongation of up to 45 percent.

The results of the thermal exposure tests, described in Table V, showed that zinc coatings suffer considerable deterioration at 700°F and powdering at 1000°F. While electrolytic and chemical nickel coatings were discolored (yellowish) at 700°F and over, no further damage was evident. In the case of "electrolized" chromium, the coating luster was unaffected at 700° but a blue discoloration occurred at 1000°F. No other damage was evident, however. The silver coatings sustained no apparent damage and retained luster at both 700°F and 1000°F as well.

NOTE:

The data from which this report was prepared are recorded in Structures Laboratory Data Book No. 4011, Pages 62 through 71.

TABLE INDEX

TABLE I
STATIC TEST RESULTS

SPEC. NO.	PLATING (1) CONDITION	U.T.S. KSI*	Y.S. KSI	% RA	% E (2")	YS/UTS
1	NONE	279.0	219.0	33.4	12.0	.786
2	"	281.0	220.0	33.9	12.5	.784
3	"	279.0	221.0	36.2	12.0	.792
53	"	282.0	222.0	39.2	13.5	.787
AVERAGE		280.2	220.5	38.2	12.8	.787
4	ZNB	280.6	221.6	8.9	6.5	.790
5	"	278.6	215.2	2.4	5.0	.772
6	"	277.8	179.1	14.4	9.5	.645
AVERAGE		279.0	205.3	8.6	7.0	.739
7	ZNB SALT	193.5	———	THREAD FAILURE	———	———
8	" "	257.6	———	" "	———	———
9	" "	280.9	———	" "	———	———
AVERAGE		———	———	———	———	———

(1) Z - ZINC PLATE 0.001 ± .0001" PER QQ-Z-325, CLASS I
Ag - SILVER PLATE 0.0004 - 0.0006" PER QQ-S-365, TYPE I
EN - ELECTROLYTIC NICKEL 0.003 ± .0001" PER QQ-N-290, CLASS II
CN - CHEMICAL NICKEL 0.005 ± .0001" PER CONVAIR SPEC. 0-05009
SALT - EXPOSURE FOR 250 HRS IN CORROSION ATMOSPHERE - SALT SPRAY
NB - NOT BAKED AFTER PLATING
B - BAKED
EE - "ELECTROLIZING" (CHROME) -.0004 - .0006"

* THREAD FAILURE SPECIMENS NOT CONSIDERED IN DATA ANALYSIS

TABLE I (CONT.)

SPEC. NO.	PLATING (1) CONDITION	U.T.S. KSI*	Y.S. KSI	% RA		% E	YS/UTS
10	ZB	—	—	THREAD	FAILURE		
11	"	277.6	172.0		38.3	12.0	.620
12	"	278.0	221.7		19.3	10.0	.795
AVERAGE		277.8	196.9		28.8	11.0	.707
13	ZB SALT	278.7	—	THREAD	FAILURE	—	—
14	"	231.9	—	"	"	—	—
15	"	278.5	—	"	"	—	—
AVERAGE		—	—		—	—	—
16	Ag NB	281.0	226.0		38.9	13.0	.805
17	" "	281.0	220.0		42.8	14.0	.784
18	" "	280.0	220.0		11.2	7.0	.785
19	" "	282.0	223.0		10.0	9.5	.790
20	" "	277.0	218.0		5.1	3.5	.787
21	" "	—	—	THREAD	FAILURE	—	—
AVERAGE		280.2	221.4		21.6	9.4	.790
54	Ag NB SALT	—	—	THREAD	FAILURE	—	—
55	" " "	279.2	—	THREAD	FAILURE	—	—
56	" " "	219.3	—	THREAD	FAILURE	—	—
AVERAGE		—	—		—	—	—

* THREAD FAILURE SPECIMENS NOT CONSIDERED IN DATA ANALYSIS

TABLE I (CONT.)

	SPEC. NO.	PLATING (1) CONDITION	U.T.S. KSI*	Y.S. KSI	% RA	% E	YS/UTS
	22	Ag B	279.3	2[illegible]9.9	43.9	13.5	.790
	23	" "	——	——	THREAD FAILURE	——	——
	24	" "	278.1	224.1	35.2	12.5	.805
	25	" "	——	——	THREAD FAILURE	——	——
	26	" "	277.2	222.1	40.0	13.0	.802
	27	" "	277.1	222.9	35.7	12.0	.806
	AVERAGE		277.9	222.2	38.7	12.8	.801
(a)	57	Ag B SALT	269.7	——	——	——	——
(a)	58	" " "	274.8	——	——	——	——
(a)	59		NO TEST	——	——	——	——
	AVERAGE		272.3	——	——	——	——
	28	EN NB	280.0	224.0	17.2	10.0	.800
	29	" "	280.5	215.9	39.0	13.5	.770
	30	" "	278.1	216.8	39.4	13.0	.780
	AVERAGE	" "	279.5	218.6	32.5	12.2	.783
	31	EN NB SALT	278.5	——	13.7	8.5	——
	32	" " "	275.6	——	THREAD FAILURE	——	——
	33	" " "	255.5	——	THREAD FAILURE	——	——
	AVERAGE		278.5	——	13.7	8.5	——

* THREAD FAILURE SPECIMENS NOT CONSIDERED IN DATA ANALYSIS

(a) UTS ONLY DATA OBTAINED

TABLE I (CONT.)

SPEC. NO.	PLATING (1) CONDITION	U.T.S. KSI*	Y.S. KSI	% RA	% E	YS/UTS
35	EN B	277.9	218.4	44.0	12.5	.788
36	" "	279.1	217.7	37.2	13.0	.780
37	" "	280.0	216.3	44.4	12.0	.773
76	" "	283.6	226.2	43.0	12.0	.799
77	" "	279.2	225.0	31.6	12.0	.807
78	" "	278.1	243.1	36.6	11.0	.874
AVERAGE		279.6	224.5	39.5	12.1	.803
38	ENB SALT	277.9	——	9.5	5.5	——
39	" "	281.1	——	13.8	8.0	——
52	" "	278.0	——	17.2	7.5	——
AVERAGE		279.0	——	13.5	7.0	——
40	CN NP	281.7	221.6	35.5	13.0	.787
41	" "	——	——	THREAD FAILURE	——	——
42	" "	——	——	THREAD FAILURE	——	——
AVERAGE		281.7	221.6	35.5	13.0	.787
43	CN WB SALT	——	——	THREAD FAILURE	——	——
44	" " "	——	——	THREAD FAILURE	——	——
45	" " "	282.1	——	39.5	14.5	——
AVERAGE		282.1	——	39.5	14.5	——

* THREAD FAILURE SPECIMENS NOT CONSIDERED IN DATA ANALYSIS

TABLE I (CONT.)

SPEC. NO.	PLATING (1) CONDITION	U.T.S. KSI*	Y.S. KSI	% RA	% E	YS/UTS
46	CN B	281.0	223.8	41.8	12.5	.795
47	" "	276.6	217.8	35.5	12.5	.787
48	" "	276.6	220.6	39.6	12.5	.798
AVERAGE		278.0	220.8	38.9	12.5	.793
49	CN B SALT	——	——	THREAD FAILURE	——	——
50	" " "	276.0	——	42.8	11.5	——
51	" " "	276.4	——	39.4	12.5	——
AVERAGE		276.2	——	41.1	12.0	——
60	EE NB	——	224.5	THREAD FAILURE AFTER YIELDING	——	——
62	" "	——	222.1	THREAD FAILURE AFTER YIELDING	——	——
63	" "	——	222.7	THREAD FAILURE AFTER YIELDING	——	——
AVERAGE		——	223.1	——	——	——
70	EE NB SALT	268.5	——	2.4	2.5	——
71	" " "	274.2	——	7.0	4.0	——
72	" " "	——	——	THREAD FAILURE	——	——
AVERAGE		270.4	——	4.7	3.3	——

* THREAD FAILURE SPECIMENS NOT CONSIDERED IN DATA ANALYSIS

TABLE II
FATIGUE TEST RESULTS - PLATED SAE 4340 STEEL
NOMINAL ULTIMATE STRENGTH = 280,000 psi TESTS AT STRESS RATIO (R) OF +.05 UNLESS SHOWN OTHERWISE

SPEC. NO.	TYPE OF DEPOSIT	DEPOSIT BAKED °F, 3 HR	MAX. STRESS (psi)	FATIGUE LIFE CYCLES	AVERAGE LIFE CYCLES	REMARKS
1	NONE	———	88,000 AT -1	553,000 (1)		THREAD FAILURE
2	"	———	" "	2,685,000 (1)		" "
3	"	———	130,000	9,070,000		NO FAILURE
3 RETEST	"	———	220,000	21,000		TEST SECTION FAILURE
4	"	———	190,000	47,000	47,000	" " "
5	ZINC	NONE	190,000	15,000		" " "
6	"	"	"	22,000		" " "
7	"	"	"	107,000		" " "
8	"	"	"	114,000	64,500	" " "
9	ZINC	375	190,000	36,000		" " "
10	"	"	"	25,000		" " "
11	"	"	"	99,000 (2)		" " "
12	"	"	"	13,000	24,700	" " "
13	SILVER	NONE	190,000	37,000		" " "
14	"	"	88,000 AT -1	495,000 (1)		THREAD FAILURE
15	"	"	190,000	35,000		TEST SECTION FAILURE
16	"	"	"	18,000	30,000	" " "

(1) TESTS AT R= -1. THREAD REWORKED AFTER THESE TESTS TO PREVENT FURTHER THREAD FAILURE

(2) OMITTED FROM AVERAGE STATISTICALLY - " RULE OF FOUR "

TABLE II (CONT.)

SPEC. NO.	TYPE OF DEPOSIT	DEPOSIT BAKED °F, 3 HR	MAX. STRESS (psi)	FATIGUE LIFE CYCLES	AVERAGE LIFE CYCLES	REMARKS
17	SILVER	375	190,000	18,000		TEST SECTION FAILURE
18	"	"	"	21,000		" " "
19	"	"	"	12,000		" " "
20	"	"	"	35,000	21,500	" " "
21	ELECT. NICKEL	NONE	190,000	14,000		" " "
22	"	"	"	16,000		" " "
23	"	"	88,000 AT -1	1,169,000 (1)		THREAD FAILURE
24	"	"	190,000	41,000	23,600	TEST SECTION FAILURE
25	ELECT. NICKEL	375	190,000	21,000		" " "
26	"	"	"	23,000		" " "
27	"	"	"	38,000		" " "
28	"	"	"	19,000		" " "
37	"	"	"	6,000		" " "
38	"	"	"	4,000	18,500	" " "
29	CHEM. NICKEL	NONE	190,000	4,000		" " "
30	"	"	"	12,000		" " "
31	"	"	"	22,000		" " "
32	"	"	"	45,000	20,750	" " "

TABLE II (CONT.)

SPEC. NO.	TYPE OF DEPOSIT	DEPOSIT BAKED °F, 3 HR	MAX. STRESS (psi)	FATIGUE LIFE CYCLES	AVERAGE LIFE CYCLES	REMARKS
33	CHEM. NICKEL	375	190,000	12,000		TEST SECTION FAILURE
34	"	"	"	19,000		" " "
35	"	"	"	9,000		" " "
36	"	"	"	7,000	11,750	" " "
39	ELECTROLIZE	NONE	190,000	6,000		" " "
40	"	"	"	6,000	6,000	" " "

TABLE III

TABOR ABRASIVE WEAR TEST RESULTS

SPECIMEN NUMBER	PLATING CONDITION	BASE METAL HARDNESS	WEAR CYCLES	AVERAGE CYCLES
1	SILVER	Rc 40	3,020	
2		" "	3,275	3,14[illegible]
3		Rc 47	3,675	
4		" "	4,000	3,838
5	ZINC	Rc 40	1,500	
6		" "	3,000	2,250
7		Rc 47	5,500	
8		" "	6,900	6,200
9	ELECTROLYTIC NICKEL	Rc 40	5,750	
10		" "	5,850	5,800
11		Rc 47	2,500	
12		" "	2,500	2,500
13	CHEMICAL NICKEL	Rc 40	7,500	
14		" "	7,500	7,500
15		Rc 47	10,300	
16		" "	10,500	10,400
17	ELECTROLIZED CHROME	CRS ANNEAL	4,000	
18		" "	4,500	
19		" "	5,000	
20		" "	6,500	5,[illegible]00

TABLE IV

CORROSION (SALT SPRAY) TEST RESULTS

PLATING TYPE	HRS EXPOSURE TO FIRST DAMAGE	EXTENT OF DAMAGE AFTER 250 HRS EXPOSURE
CHEMICAL NICKEL	250	PINHOLE CORROSION JUST BEGINNING TO APPEAR
SILVER	200	SMALL ISOLATED AREAS OF CORROSION DEVELOPED FROM PINHOLES
E-NICKEL AND ELECTROLIZED CHROME	96	GENERAL DETERIORATION OF SURFACE WELL UNDER WAY
ZINC	48	PLATING AND UNDER SURFACE HEAVILY DAMAGED

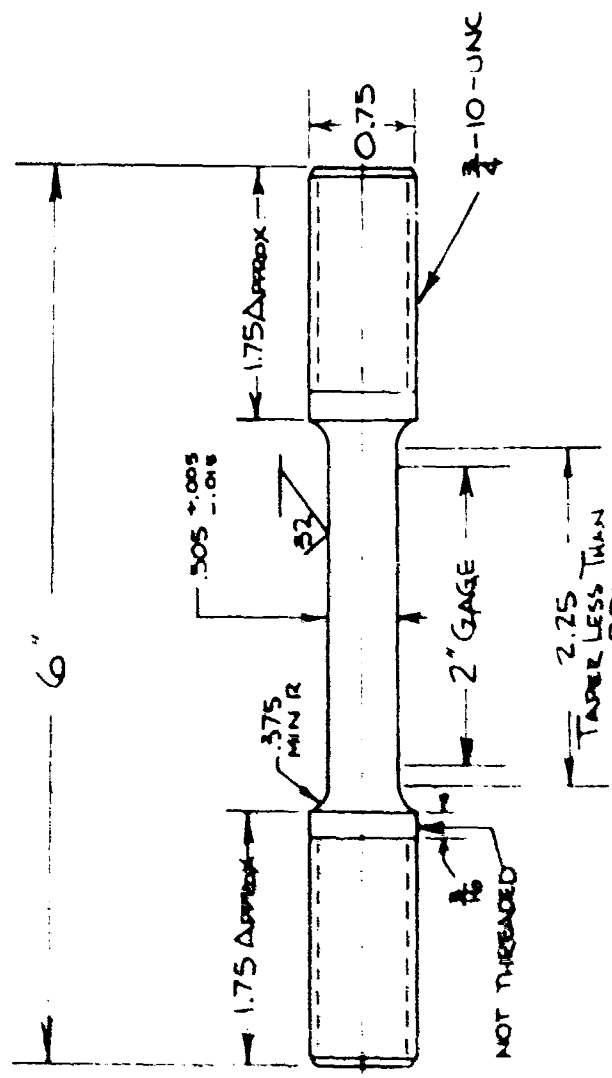
TABLE V

THERMAL EXPOSURE TEST RESULTS

PLATING TYPE	EFFECT ON PLATING OF 700 °F - 1 HR	EFFECT ON PLATING OF 1000 °F - 1 HR
ZINC	PLATING PEELED OFF EASILY - DISCOLORED	PLATING BECAME POWDERED AND EASY TO RUB OFF - DISCOLORED
SILVER	NO DAMAGE EVIDENT RETAINED LUSTER	SAME AS 700 °F
ELECTROLYTIC NICKEL	NO PEELING OR OTHER DAMAGE EVIDENT - DISCOLORATION QUITE NOTICEABLE - YELLOWISH	SAME AS 700 °F
CHEMICAL NICKEL	NO PEELING OR OTHER DAMAGE EVIDENT - DISCOLORATION QUITE NOTICEABLE - YELLOWISH	SAME AS 700 °F
"ELECTROLIZED" CHROME	NO DAMAGE EVIDENT RETAINED LUSTER	NO DAMAGE EVIDENT PROMINENT DISCOLORATION BLUE

FIGURE INDEX

ALTERATION	DATE	NAME



DRAWN	FORNEY		STANDARD TENSILE SPECIMEN	PART NUMBER
CHECKED			CONVAIR	
APPROVED			SAN DIEGO	

FIGURE 1

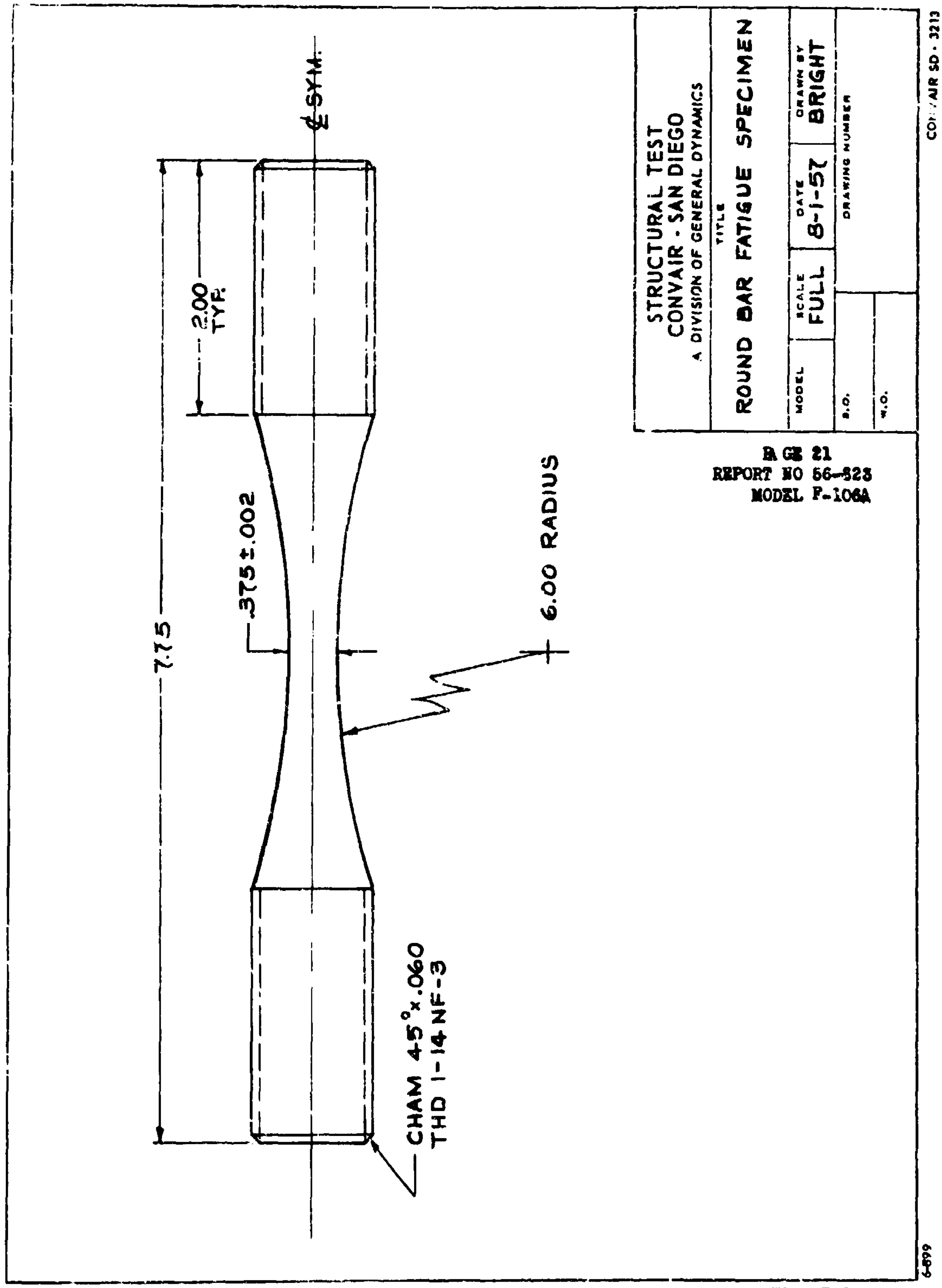

STRUCTURAL TEST
CONVAIR - SAN DIEGO
A DIVISION OF GENERAL DYNAMICS
TITLE
ROUND BAR FATIGUE SPECIMEN
MODEL
SCALE FULL
DATE 8-1-57
DRAWN BY BRIGHT
DRAWING NUMBER
B.O.
W.O.
CONVAIR SD - 3213
℄ SYM.
2.00 TYP.
7.75
.375 ±.002
6.00 RADIUS
CHAM 45° x .060
THD 1-14 NF-3
6-899

FIGURE 2

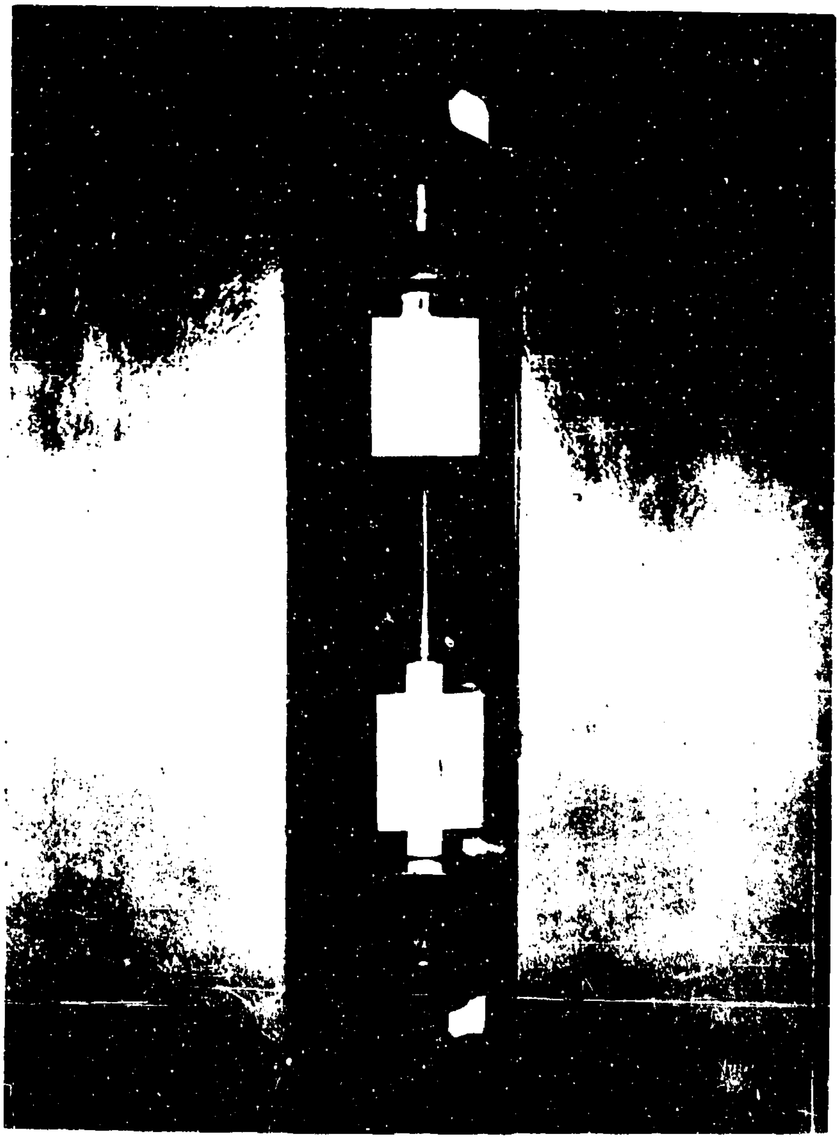


FIGURE 5 FATIGUE TEST SETUP

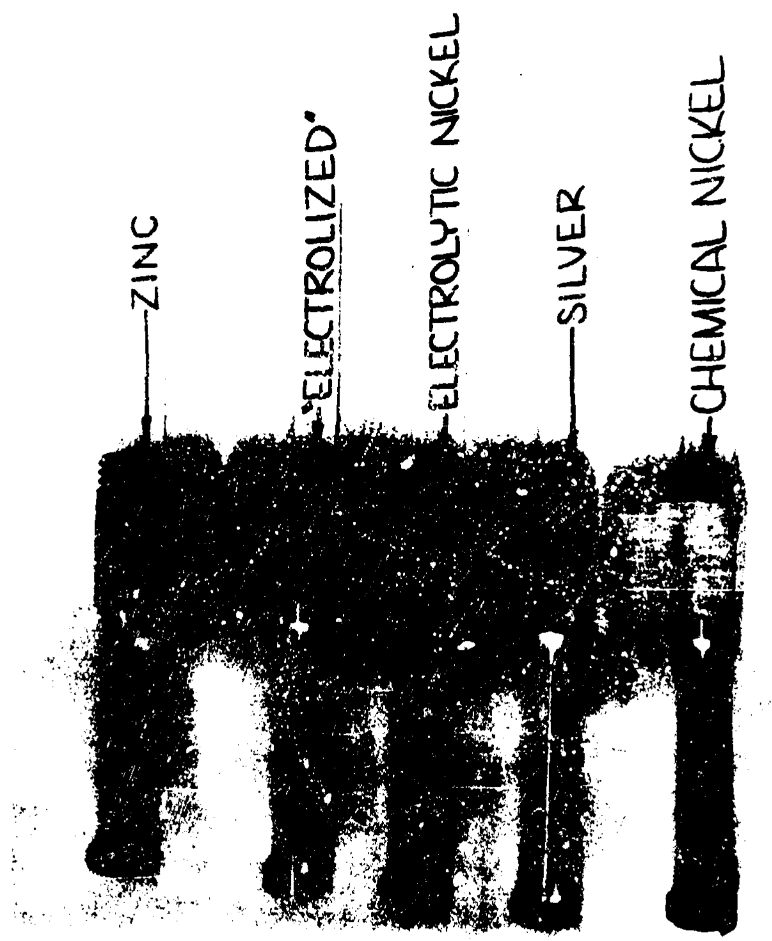


FIGURE 4 CORROSION TEST SAMPLES - 250 HR SALT SPRAY EXPOSURE

FIGURE 5 ABRASIVE WEAR TEST SETUP

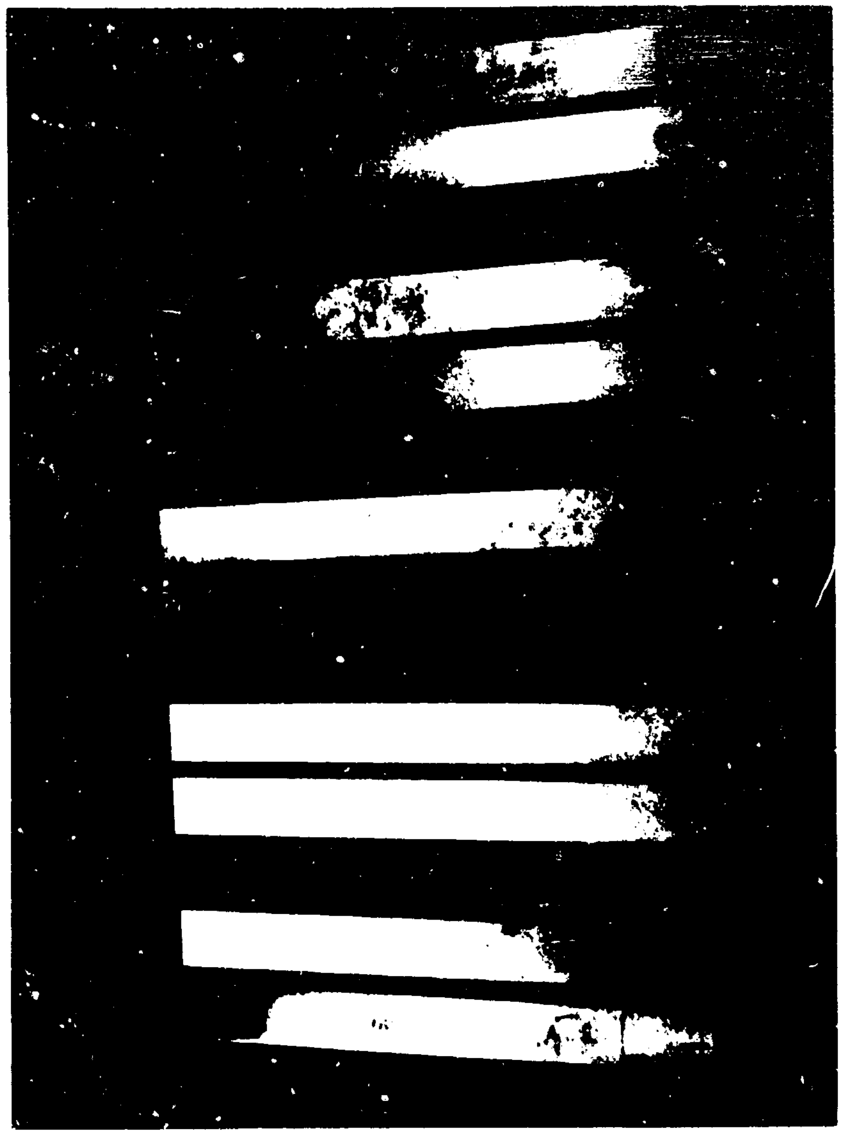


FIGURE 6 THERMAL EXPOSURE TEST SAMPLES